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(54) **Method of manufacturing ceramic artificial tooth restorations**

Verfahren zur Herstellung keramischen Zahnersatzes

Procédé de fabrication d'éléments de reconstitution d'une dent en céramique

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Description

This invention relates to powder metallurgical manufacturing methods for making accurately shaped artificial tooth restorations with an individually manufactured core of a densely sintered, high strength ceramic material, which fits against prepared tooth surfaces or artificial abutments. On these cores dental porcelain can be fired to tooth crowns, inlays, veneers or bridges.

U.S. 5,080,589 (EP-A-0 375 647) discloses a method of manufacturing copings in densely sintered, high strength ceramic material where the sintering shrinkage is considered. According to this patent the copings are premanufactured, which means that they have in advance given measure.

U.S. 5,106,303 (EP-A-0 389 461) and the Swedish patent SE 469 057 disclose manufacturing of inlays, onlay crowns and veneers in densely sintered, high strength ceramic material by copy milling a green body or a presintered or sintered body from an impression of the prepared tooth surface and considering the sintering shrinkage.

The object of the present invention is to provide a rational manufacturing technique for manufacturing tooth crowns, inlays, veneers or bridges in densely sintered, high strength ceramic material by using modern powder metallurgical technique and reading technique.

The present invention relates to a method of manufacturing with powder metallurgical methods artificial tooth restorations for natural tooth or implants containing an individual core in densely sintered, high strength ceramic material with dental porcelain fired to the surface. The inner surface of the core, which will fit to one or more prepared surfaces or artificial abutments is manufactured by forming a ceramic powder mixture against a surface of a body at which mentioned surface is manufactured by a three dimensional optical or mechanical reading method, register the prepared surfaces of the prepared tooth or artificial abutments and their mutual relationship, either directly in the mouth or on a model in e.g. plaster after which the registered surfaces are reproduced in an enlarged size e.g. by using a computer controlled milling machine, the enlargement being calculated by considering the shrinkage of the ceramic material during the sintering to full density with the addition of a desired gap for cement.

Fig. 1 shows cross sections of natural teeth one with an artificial tooth crown (Fig.1a) one with an inlay (Fig. 1b), and one with a veneer (Fig. 1c). In this figure A= dental porcelain, B= core in densely sintered ceramic, Y= the outer surface of the core, I= the inner surface of the core, C= cement, P= the prepared surface of the tooth, S= the preparation border, E= enamel, D= dentin and F= pulp.

Fig. 2 shows a cross section of a bridge, which is cemented on two supporting teeth. These supporting teeth can have a vital abutment (U_1) or an artificial abutment (U_2) manufactured in a dental alloy, ceramic material or a strengthened polymer. The bridge in Fig. 2 contains two artificial dental crowns according to Fig. 1a and with a pontic (V) between as replacement for a lost tooth. The bridge contains a core (B) with dental porcelain (A). A bridge can contain more supporting teeth and also more pontics in between. The supporting teeth can also be prepared for inlays or veneers. Veneers can be made both buccaly and lingually. The supporting teeth can also be implants with artificial abutments.

Fig. 3 shows a cross section of an example of a press for individual cores for tooth crowns. K_1 is a model of a preparation for a tooth crown enlarged considering the sintering shrinkage. S is the preparation border, T the top of the model, R its bottom and L the surface, which is the enlarged surface of the preparation (P). K_2 consists of K_1 with a coping of e.g. wax and Z is the outer surface of this coping. F is a tube. G_1 is a plate with a cylinder G, which fits into F. H is a cylinder, which also fits into F. H, F, E, G and G_1 can be made in e.g. metallic material E is made in a viscous elastic material as well as J and X, which are impressions of K_2, M is a cavity with space for ceramic powder. K_1 has been placed in X and P_k is the force with which H is pressed against G.

Fig. 4 shows a cross section of an impression of two supporting teeth prepared for crowns and the gingiva between the teeth. c_1 and c_2 are the impressions of the preparations of the supporting teeth in a, which is the impression material. b_1 and b_2 are two parallel tubes firmly united to each other with b_3. The inner surfaces of bland b_2 consist of two cylinder surfaces with radii r_1 and r_2. They are connected with e_1-e_2. w is the angle between the parts of b_1 and b_2 with radius r_1 and the surface with the cross section e_1-e_2. q_1 and q_2 are grooves in the part of the tubes b_1 and b_2 with radius r_2. h is the distance between the parallel central axes of b_1 and b_2. n_1 and n_2 are models of c_1 and c_2 made by pouring model material e.g. plaster in the tubes b_1 and b_2 and c_1 and c_2.

Fig. 5 shows N_1 and N_2 which are enlarged (compensated for the shrinking during sintering) models of n_1 and n_2. f is a fixture with the holes g_1 and g_2, manufactured so that the distance H between the central axes of g_1 and g_2 is h when enlarged considering the sintering shrinkage as well as the inner shape of the holes g_1 and g_2, which are enlarged from the inner surface of the tubes b_1 and b_2. Q_1 and Q_2 are the enlarged grooves q_1 and q_2.

Fig. 6 shows N_1 and N_2 placed in the fixture f. X_1 is a tool made in a rubber material and M_1 is a cavity.

As can be seen from Fig. 1 and Fig. 2 artificial tooth crowns, inlays, veneers or bridges are made as a core in densely sintered ceramic (B) with dental porcelain fired to the surface (A). The tooth restorations are fixed to the prepared surfaces(P) by e.g. cementing, as well as the bridge to the abutments U_1 and U_2. The thin layer of cement (C) connects the prepared cavity walls (P) with that part of the surface of the inner surface of the

core (I), which has been made so that this surface (D) fits with great precision to the prepared surface (P). On the outer surface (Y) of the core (B) dental porcelain can be fired. The layer of cement can have a thickness <100 µm, preferably 25-50 µm. The cementing of the restorations can be made with e.g. zinc phosphate cement, glass-ionomer cement or some resin cement. In the last case it can be an advantage to silane treat the inner surfaces (I) of the cores of the constructions, which will be joined with the prepared surfaces (P) of the tooth structure as well as it also can be advantageous to etch and treat the prepared surfaces (P) with a bonding resin before the cementation.

The ceramic powder can be made by several for the expert well known methods. Traditional powder metallurgical technique can be used, where the different components are mixed and ground under dry or wet conditions with water or an inorganic solvent (e.g. alcohols) as grinding liquid. To the ceramic slurry lubricants or other organic binders depending on the choice of forming method are added, when needed at suitable time in the process.

The ceramic base material in the core preferably comprises one or several biocompatible oxides, with additives of carbides and nitrides with or without binders. Examples of biocompatible oxides, which can form base matrix for the ceramic body, are Al_2O_3, TiO_2, MgO, ZrO_2, and ZrO_2 with additives of smaller amounts of up to 10 mole-% of Y_2O_3 or MgO (partly or totally stabilized ZrO_2). Additives can be present as particles with a size of <25 µ m, preferably <10 µm and/or as whiskers (hair shaped single crystals) with a length of >10 µm, preferably >25 µm and a length to diameter ratio >5, preferably >10 and/or fibers (polycrystalline) with a diameter >10 µm and/or as single crystal platelets with an approximate diameter of 5-50 µm and a thickness of 1-10 µm. The amount of whiskers, fibers and/or platelets should not exceed 60 volume%.

In a preferred embodiment the ceramic material comprises >50% Al_2O_3 with additives of conventional sintering aids. In order to increase the strength <25 weight %, preferably 3-12 weight % of ZrO_2, and/or 5-40 weight %, preferably 10-30 weight % of SiC-, TiN- or ZrN-whiskers can be added. It is important that the ceramic material is sintered to closed porosity, which for an oxide material means at least 95% of theoretical density, but in order to ensure good mechanical strength the material should preferably have a density over 98%, densities over 99.5% giving the best strength.

In order to get a suitable colour of the core (B) coloured components can be chosen. Additives e.g. 0.1-1 weight % of TiN and/or ZrN will give Al_2O_3 based cores a faint yellow shade. Fe_2O_3 gives a yellow brown shade and MnO_2 gives a rose-coloured shade. Of course, additives, which give non-estetic effects, should not be used.

According to the invention artificial ceramic tooth crowns, inlays, veneers and bridges now exist characterized in that they are made from a ready to press powder with additions of lubricants and/or other organic binders. When manufacturing the core of a individual tooth crown the powder is compacted against the body K_1 to a core, which after sintering to full density fits to the prepared surface and with a desired wall thickness. When manufacturing the enlarged model (K_1) the sintering shrinkage has to be considered. The surface (L) must be enlarged in order to have the desired inner geometrical shape (I) of the green body, which fits against the prepared surface (P) after subsequent sintering process. The desired shape of the gap between the tooth crown and the prepared tooth for cementing the crown to the prepared tooth must also be considered. The size of this gap can be calculated e.g. to be as small as possible at the preparation border.

The cores of the tooth crowns are manufactured by cold isostatic compaction, uniaxial pressing, slip casting, pressure casting, injection moulding or by compacting the powder in another way, preferably by a cold isostatic technique against a body (K_1), which is shown in Fig. 3. K_1 has a surface (L), which is uniform with the surface (P) of the prepared tooth, on which the tooth crown or the veneer will fit. The body (K_1) is manufactured by registering the prepared surface (P) or an artificial abutment directly in the mouth or from a model e.g. in plaster by a three dimensional mechanical or optical method. The registered surface is reproduced in an enlarged size (L) e.g. with a computer controlled milling machine. The enlargement is calculated from the shrinkage of the ceramic material during sintering to full density. When calculating the shape of K_1 the gap for cement is considered. It is important that the preparation border S respectively S_1 are evident. Below the preparation border S_1 between S_1 and the bottom R the body (K_1) is given such a shape that its surfaces converge to the occlusal part of the preparation. At the bottom (R) the outer surface can be e.g. cylindrical. The body (K_1) can be manufactured in e.g. metallic material, graphite, polymers et cetera. K_1 will have such a size that the inner surface of the green body (the impression of L) after shrinkage during sintering to full density receives the inner surface I, which has desired fit against the prepared tooth surface (P) or to an artificial abutment. The surface (L) of the body K_1 is manufactured with a computer controlled milling machine, which enlarges the registered tooth surface, will after compacting the powder against this surface (L) and sintering to full density give the inner shape of the core (I). During compaction the outer surface (Y) of the core is formed as follows: A body (K_2), which is shown in Fig. 3 is milled with a computer controlled milling machine from registered data from the prepared surface (P) of the registered tooth or the surface of the artificial abutment. This body (K_2) is enlarged considering the sintering shrinkage in the same way as the body K_1 and with an additional material from the preparation border or just below. K_2 contains the outer surface Z. The outer surface Z can

be formed by forming a coping in any easily moldable material e.g. wax or a material, which easily can be formed against the body K_1. The outer surface (Z) of this second body (K_2) or (K_1) with a coping in e.g. wax is used to form the outer shape (Y) of the core. An impression (X) is made from the body (K_2), or K_1 with a coping in e.g. wax in some viscous elastic material e.g. a silicone. The compaction of the powder can be made with tool according to Fig. 3. This tool contains the impression X. K_1 fits into X from the bottom (R) to the preparation border S. Between the surface (L) of K_1 and X there is a cavity M. The impression X has such a shape as to fit into a body E, which can contain a viscous elastic material. The body E is placed into a tube (F), which is put on G, which is a part of G_1. The cylinder (H) with the same diameter as G is put into the tube (F) from the top. Between H and E containing X is a lid (J) placed in the same material as E.

The manufacture of an individual core to a tooth crown can be made in the following way: The pressing tool is put together with the tube F on the cylinder G. E with X is put into the tube F. Ready to press powder is filled into the cavity M and the body K_1 is fit into X. K_1 fits into the impression X from the preparation border S_1 or just below and to the bottom R of the body K_1. Finally, the lid J and the cylinder H are placed and the whole tool according to Fig. 3 is put into a press e.g. a uniaxial hydraulic press. During the compaction of the powder the cylinder H is pressed with the force P_k in the tube F against the cylinder G in contact with the lid J and the powder is compacted against the body K_1. After the compaction H, J and K_1 are removed and the compacted shell, which in some cases can be attached to K_1. K must not contain any undercuts. The wall thickness of the green body is determined by the amount of powder put into M. After the pressing the green body is adjusted at the preparation border (S_1) and the wall thickness is controlled and adjusted before the sintering to full density. The wall thickness can be 0.5 mm, however, on certain places wall thicknesses >0.5 mm can be needed in order to strengthen marginal ridges or for replacement of removed fillings. After sintering to full density the core (B) is adjusted against the preparation border (S) of the plaster model in order to fit the surface I of the core against the surface P of the prepared tooth or against the artificial abutment. Finally dental porcelain can be fired to the core for the manufacture of a tooth crown.

A veneer can be manufactured in the same way as above.

A core (B) of an inlay can also be manufactured by registering the surface (P) prepared for an inlay by a three dimensional mechanical or optical method. The registered tooth surface is reproduced in an enlarged size in a metal, graphite or a polymer e.g. with a computer controlled milling machine, which enlarges the preparation. The enlargement is calculated from the shrinkage of the ceramic material during sintering to full density and with a reduction for the cement. An impression (X) (Fig. 3) can be manufactured in the same way, as for a core of a tooth crown. Before the manufacturing of the impression X for an inlay the enlarged preparation is overfilled with e.g. wax. This enlarged model with the filled preparation cavity is used for the manufacture of the impression X in some viscous elastic material e.g. a silicone. This impression is placed in a press in the same way as described in Fig. 3 after the ceramic powder has been put in the cavity between the enlarged model and the impression X. After the compaction the green body is removed. In order to be able to remove the green body without destroying it, the preparation must not contain any undercuts. The green body is adjusted against the preparation border and space can be given if dental porcelain will be fired to the outer surfaces of the inlay, that means the surfaces which are not cemented against the prepared surfaces of the tooth. After the sintering of the core some adjustment by grinding or polishing can be needed.

When manufacturing a bridge it is important to maintain the mutual relationship after the enlargement. A bridge can be manufactured by starting with the registration of the surfaces of the prepared tooth and the soft tissue in between by a three dimensional mechanical or optical method. It is important to register the mutual relationship of the supporting teeth which can be done in the following way. An impression is made with conventional impression technique e.g. with a silicone impression material. This impression is cast in e.g. plaster. From this model or directly in the mouth the prepared teeth and the jaw in between is registered by a three dimensional mechanical or optical method. The prepared teeth and the tooth free jaw in between are reproduced in an enlarged size with e.g. a computer controlled milling machine. The enlargement is calculated from the shrinkage of the ceramic material during sintering to full density and with an additional space for the cement. The material in the enlarged models can be e.g. graphite, metal or a polymer.

An enlarged model which considers the whole situation can also be made in the following way. An impression as shown in Fig. 4 is made from the supporting teeth and the tissue in between with a conventional impression technique e.g. with an impression material in e.g. a silicone material (A). Fig. 4 shows a cross section of an impression. The tubes b_1 and b_2 are pressed into the impression material (a). In order not to deform the impression of the preparations that part of the tubes pressed into the impression material can e.g. have a chamfered edge. The tubes can also be fixed to the impression with e.g. sticky wax. The tubes b_1 and b_2 can e.g. have elliptic or circular cross section with grooves (q_1 and q_2) in the longitudinal axis in the internal surfaces of the tubes, and a step e_1-e_2, is clear from a cross section parallel with the longitudinal axes. The tubes b_1 and b_2 have parallel longitudinal axes and surround the impressions (c_1 and c_2) of the preparations of

the supporting teeth in the impression material (a). The tubes b_1 and b_2 are fixed to each other with b_3. The impressions (c_1 and c_2) are poured out in e.g. plaster, which gives the models (n_1 and n_2) shown in Fig. 4. The models n_1 and n_2 are registered with a three dimensional mechanical or optical method and are reproduced in an enlarged size with e.g. a computer controlled milling machine. The enlargement is calculated from the shrinkage of the ceramic material during sintering to full density and with an additional space for the cement above the preparation border (S_1) of the models N_1 and N_2. The material of N_1 and N_2 can be e.g. metallic material, graphite or a polymer. These enlarged models (N_1 and N_2) are put into a fixture f as shown in Fig. 5. The fixture f contains a plate in e.g. a metal, which has two holes g_1 and g_2. These holes have a geometry, which is uniform with the internal surfaces of the tubes b_1 and b_2 and enlarged with the same enlargement factor considering the sintering shrinkage for the current ceramic powder. The distance (H) between the longitudinal axes of the holes is enlarged considering the sintering shrinkage of the ceramic material. By placing the enlarged models N_1 and N_2 in the fixture f an enlarged model of the prepared supporting teeth and their mutual relationship is made. The step E_1-E_2 and the grooves Q_1 and Q_2 and the distance (H) give the mutual relationship of the enlarged preparations. The manufacturing of the tool for compacting the ceramic powder to the bridge is made in a similar way as is shown in Fig. 3. An impression X has to be made which gives space for powder to a beam which connects the copings, which after the compaction will fit the enlarged preparations N_1 and N_2. Fig. 6 is an outline figure of the impression X. In Fig. 6 the models N_1 and N_2 put in the fixture f are placed in the impression X, manufactured in the same way as has been described for cores of single tooth crowns. In the empty space M_1, which surrounds N_1 and N_2, ceramic powder is placed and the tool is put in a pressing tool according to Fig. 3 and a compacting pressure P_k is applied. The ceramic powder will be compacted against N_1 and N_2 and against the part of the fixture, which is situated between N_1 and N_2. The green body is removed and the copings are adjusted at the preparation border and where the wall thickness needs reduction. The beam can be formed with e.g. a milling cutter in a hand piece of a dental technician in order to give it a suitable form as a substructure of pontics. The core is sintered to full density. After the sintering some adjustment can be needed before the firing of dental porcelain to the core to have a bridge according to Fig. 2.

The manufacturing of a bridge the mutual relationship of the supporting teeth can be maintained after the enlargement in many other ways e.g. before the impression (a) is cast some markers are placed in the impression in such a way that they give impressions in the different parts (the supporting teeth and the jaw in between) into which the plaster model will be divided by sawing. The impressions of the markers in combination with enlarged markers can be used to have the mutual relationship of the supporting teeth after the enlargement.

A bridge can also be manufactured, which is based on supporting teeth with preparations for a veneer on the buccal surface or a preparation on the lingual surface for a lingual plate. The manufacture of such a bridge can be made in the same way as has been described for a bridge with supporting teeth prepared for full crowns.

A bridge can also be made for supporting teeth prepared for inlays. In order to have the mutual relationship between the supporting teeth in the enlarged model considering the sintering shrinkage, the manufacture of compaction tool and the compaction are made in the same way as described for a bridge with supporting teeth prepared for full crowns. The supporting teeth can have different types of preparations.

A bridge based on supporting teeth prepared for inlays can also be made in densely sintered, ceramic material by starting from e.g. a plaster model of the prepared teeth and the jaw between. A beam can be made by using a light hardened polymer filled into the inlay preparations and connecting the preparations of the bridge. Before the hardening of the polymer it is given such a shape that the inlays and the beam between have the desired form. After the light hardening of the polymer bridge it is removed and is registered by a three dimensional mechanical or optical method and reproduced in an enlarged size to a green body or a presintered ceramic body with e.g. a computer controlled milling machine. The enlargement is calculated from the shrinkage of the ceramic material during sintering to full density.

Another way of manufacturing a densely sintered shell, which after sintering to full density fits to a prepared tooth, is to make an impression of the enlarged body K_1 considering the sintering shrinkage and an additional space for the cement according to Fig. 3. This impression is cast in plaster and a model K_3 in plaster is obtained from K_1. An impression (X) is made according to Fig. 3. Against K_3 ceramic powder is compacted with e.g. the compaction tool described in Fig. 3. The green body is presintered on the plaster model. Alumina is presintered at 800°C-1100°C. During the presintering water is released from the plaster, which shrinks about 15%. The ceramic material shrinks much less and the presintered core can easily be removed, adjusted and sintered to full density.

Further, another way of manufacturing a densely sintered shell, which after sintering to full density fits on a prepared tooth, is to make a slurry of ceramic powder mixed and ground under wet conditions with water or an inorganic solvent (e.g. alcohols) as grinding liquid. To the ceramic slurry lubricants or other organic binders are added. On the enlarged plaster model K_3 of the prepared tooth the slurry of the ceramic powder is placed in

some way e.g. with a brush from the preparation border (S_1) to the top (T). The plaster model of K_1 (K_3) can also be dipped into a slurry of the ceramic powder. In order to have an optimal compaction of the powder, a suction cup can be applied to the bottom surface (R) and by the suction cup a negative pressure is applied during the dipping of the body K_3 into the slurry as described in the Swedish patent application no. 9004134-4. The ceramic particles will be packed against the plaster model, when this model absorbs the water from the slurry. In this way the ceramic powder is compacted against the plaster model and the body compacted in this way can be adjusted at the preparation border S_1 and adjusted to desired shape and shell thickness of the core. The green body is presintered on the plaster model. The presintered body will be too big for the plaster model and can be removed for any adjustment and sintering to full density. Instead of plaster other porous materials can be used provided that they can be used as sintering support during the presintering.

Bridges can be manufactured with above described slip casting method by making an impression from N_1 and N_2 in the fixture f (Fig. 5) and cast in e.g. plaster. Before the impression is made a support for the slurry to make the substructure for the pontics is built up with e.g. wax on the fixture between N_1 and N_2. An impression is made of the fixture with the support (N_1 and N_2) for the pontics, which is cast in plaster. The plaster model is fixed to a plate in some ceramic material and is divided into three parts (N_1, pontic and N_2). The three parts have the same mutual relationship as before the separation. Against the plaster model a slurry is placed in the same manner as was described for cores for single tooth crowns. The separated and fixed plaster model with the ceramic slurry is presintered and the presintered bridge core can, if needed, be adjusted before the sintering to full density.

Another way of manufacturing a core of a bridge is to compact ceramic powder with a tool shown in Fig. 6 against N_1 and N_2 in the fixture f according to Fig. 5 or against a plaster model according to Fig.5 fixed and separated into three parts. The tool is placed in a compaction tool similar to that shown in Fig. 3 after the ceramic powder has been placed into M_1. The green body manufactured in this way is adjusted before the presintering. After the presintering the body can have any adjustment before the sintering to full density in a known way.

Claims

1. Method of manufacturing artificial tooth restorations comprising a ceramic densely sintered, high strength individual core (B) with dental porcelain (A) by powder metallurgical manufacturing methods **characterized** in that the inner surface (I) of the core (B), which will fit against one or more prepared tooth surfaces (P) or artificial abutments is manufactured by forming a ceramic powder mixture against a surface of a body at which this mentioned surface is manufactured by registering the surfaces of the prepared teeth or artificial abutments and their mutual relationship with a three dimensional optical or mechanical reading method directly in the mouth or on a model in e.g. plaster after which the registered surfaces are reproduced in an enlarged size e.g. with a computer controlled milling machine, the enlargement being calculated from the shrinkage of the ceramic material during sintering to full density and considering the gap for cement.

2. Method according to claim 1 **characterized** in that the outer surface (Y) of the core (B) is dry pressed close to desired size against the enlarged preparations with the help of an impression (X) in some viscous elastic material.

3. Method according to claims 1 and 2 **characterized** in that the core is made by a dry pressing against a e.g. plaster model of the enlarged preparations, after which the core is presintered on the plaster model.

4. Method according to claim 1 **characterized** in that the core in manufactured by slip casting against e.g. a plaster model of the enlarged preparations, after which the core is presintered on the plaster model.

5. Method according to claims 1, 2, 3 and 4 **characterized** in that the core consists of high strength densely sintered, ceramic material with a relative density of > 99%.

6. Method according to claim 5 **characterized** in that the ceramic material in the core is based on one or more of the oxides Al_2O_3, TiO_2, MgO, ZrO_2 or ZrO_2 with up to 25 mole% Y_2O_3 or MgO.

7. Method according to claims 5 and 6 **characterized** in that the core material also comprises whiskers and/or particles of SiC, TiN, ZrO_2 and/or ZrN.

Patentansprüche

1. Verfahren zur Herstellung von künstlichem Zahnersatz mit einem keramischen, dichtgesinterten einzelnen Kern (B) hoher Festigkeit mit Dentalporzellan (A) durch pulvermetallurgische Herstellungsmethoden, **dadurch gekennzeichnet**, daß die innere Oberfläche (I) des Kerns (B), welche auf eine oder mehrere vorbereitete Zahnflächen (P) oder künstliche Halteteile paßt, hergestellt wird, indem man ein Keramikpulvergemisch auf einer Oberfläche eines Körpers bildet, auf welchem

diese erwähnte Oberfläche durch Vermessen der Oberflächen der vorbereiteten Zähne oder künstlichen Halteteile und ihrer wechselweisen Beziehung mit einer dreidimensionalen optischen oder mechanischen Lesemethode direkt im Mund oder auf einem Modell, beispielsweise aus Gips, hergestellt wird, wonach die vermessenen Oberflächen in einer vergrößerten Größe, z. B. mit einer computergesteuerten Fräsmaschine, reproduziert werden, wobei die Vergrößerung aus der Schrumpfung des Keramikmaterials während des Sinterns zu voller Dichte und Berücksichtigung des Spaltes für Zement berechnet wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß die äußere Oberfläche (Y) des Kerns (B) nahe der erwünschten Größe gegen die vergrößerten Präparate mit Hilfe eines Abdruckes (X) aus einem viskosen elastischen Material trockengepreßt wird.

3. Verfahren nach Anspruch 1 und 2, **dadurch gekennzeichnet**, daß der Kern durch Trockenpressen gegen beispielsweise ein Gipsmodell der vergrößerten Präparate hergestellt wird, wonach der Kern auf dem Gipsmodell vorgesintert wird.

4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß der Kern durch Schlickergießen beispielsweise auf einem Gipsmodell der vergrößerten Präparate hergestellt wird, wonach der Kern auf dem Gipsmodell vorgesintert wird.

5. Verfahren nach den Ansprüchen 1, 2, 3 und 4, **dadurch gekennzeichnet**, daß der Kern aus dichtgesintertem Keramikmaterial hoher Festigkeit mit einer relativen Dichte von >99 % besteht.

6. Verfahren nach Anspruch 5, **dadurch gekennzeichnet**, daß das Keramikmaterial in dem Kern auf einem oder mehreren der Oxide Al_2O_3, TiO_2, MgO, ZrO_2 oder Zr O_2 mit bis zu 25 mol% Y_2O_3 oder MgO basiert.

7. Verfahren nach Anspruch 5 und 6, **dadurch gekennzeichnet**, daß das Kernmaterial auch Whisker und/oder Teilchen von SiC, TinN, ZrO_2 und/oder ZrN umfaßt.

Revendications

1. Procédé de fabrication d'éléments de reconstitution de dent artificielle comprenant un noyau individuel à résistance élevée en céramique frittée de façon dense (B) ainsi que de la porcelaine dentaire (A) par des procédés de fabrication de métallurgie des poudres, caractérisé en ce que la surface interne (I) du noyau (B), qui s'adaptera contre une ou plusieurs surfaces de dents préparées (P) ou piliers artificiels, est fabriquée en formant un mélange de poudre de céramique contre une surface d'un corps par rapport auquel cette surface mentionnée est fabriquée en enregistrant les surfaces des dents préparées ou des piliers artificiels ainsi que leur relation mutuelle à l'aide d'un procédé de mesure optique ou mécanique tridimensionnelle directement dans la bouche ou bien sur un modèle, par exemple en plâtre, après quoi les surfaces enregistrées sont reproduites à échelle agrandie, par exemple à l'aide d'une machine de fraisage commandée par ordinateur, l'agrandissement étant calculé à partir du retrait du matériau de céramique pendant le frittage jusqu'à densité complète, et en prenant en compte l'interstice destiné au ciment dentaire.

2. Procédé selon la revendication 1, caractérisé en ce que la surface extérieure (Y) du noyau (B) est compactée à sec jusqu'à la dimension désirée contre les préparations agrandies à l'aide d'une empreinte (X) dans un matériau élastique visqueux quelconque.

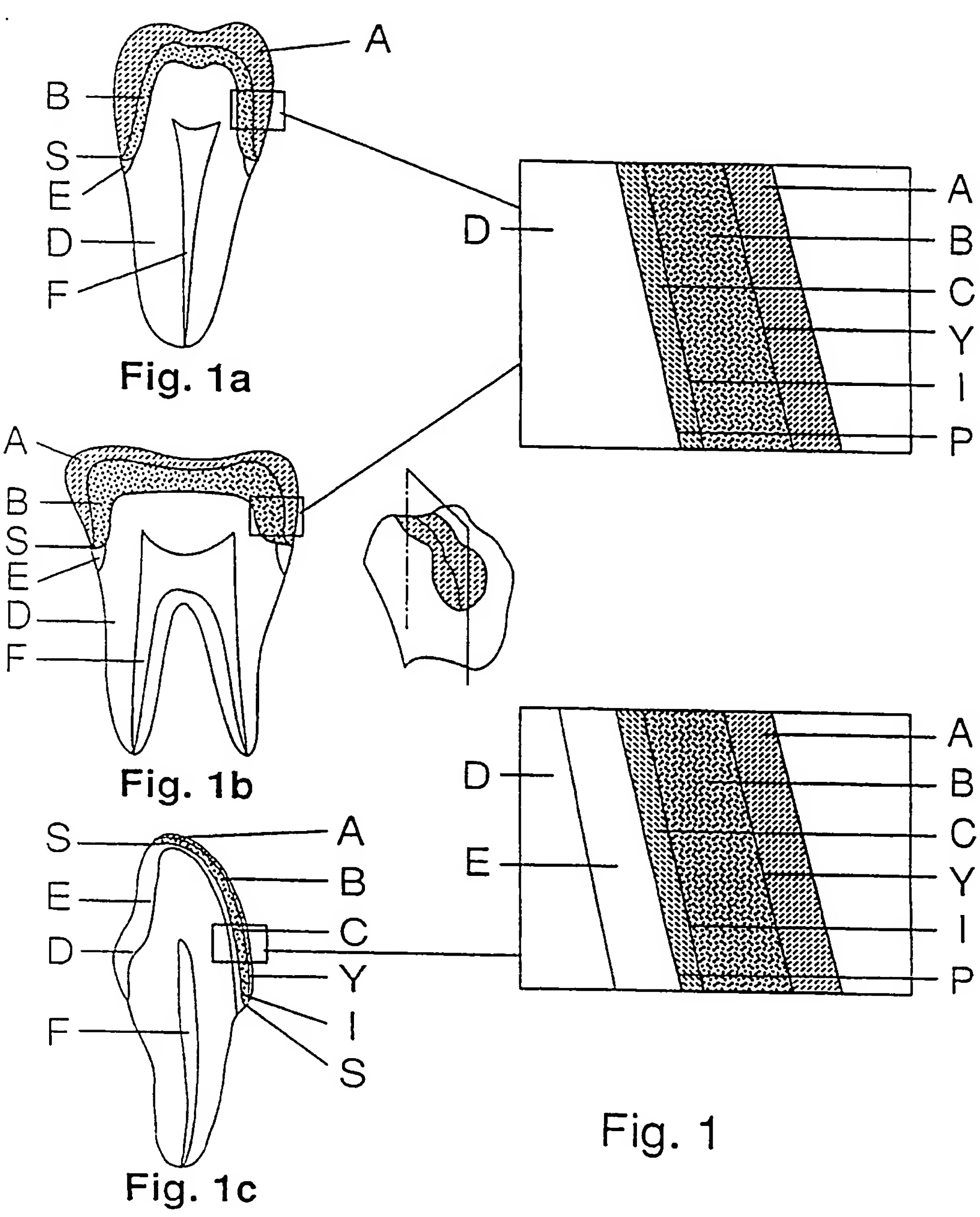
3. Procédé selon les revendications 1 et 2, caractérisé en ce que le noyau est fabriqué par compression à sec contre un modèle, par exemple en plâtre, des préparations agrandies, après quoi le noyau est pré-fritté sur le modèle en plâtre.

4. Procédé selon la revendication 1, caractérisé en ce que le noyau est fabriqué par coulée en barbotine contre un modèle, par exemple en plâtre, des préparations agrandies, après quoi le noyau est préfritté sur le modèle en plâtre.

5. Procédé selon les revendications 1, 2, 3 et 4, caractérisé en ce que le noyau est constitué d'un matériau de céramique fritté de façon dense à résistance élevée, présentant une densité relative supérieure à 99 %.

6. Procédé selon la revendication 5, caractérisé en ce que le matériau de céramique du noyau est à base de l'un ou de plusieurs des oxydes Al_2O_3, TiO_2, MgO, ZrO_2, ou ZrO_2 avec jusqu'à 25 % molaire de Y_2O_3 ou de MgO.

7. Procédé selon les revendications 5 et 6 caractérisé en ce que le matériau du noyau comprend également des barbes et/ou des particules de SiC, TiN, ZrO_2 et/ou ZrN.


A
B
S
E
D
F
Fig. 1a
D
A
B
C
Y
I
P
A
B
S
E
D
F
Fig. 1b
D
E
A
B
C
Y
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P
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A
E
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C
D
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F
I
S
Fig. 1c

Fig. 1

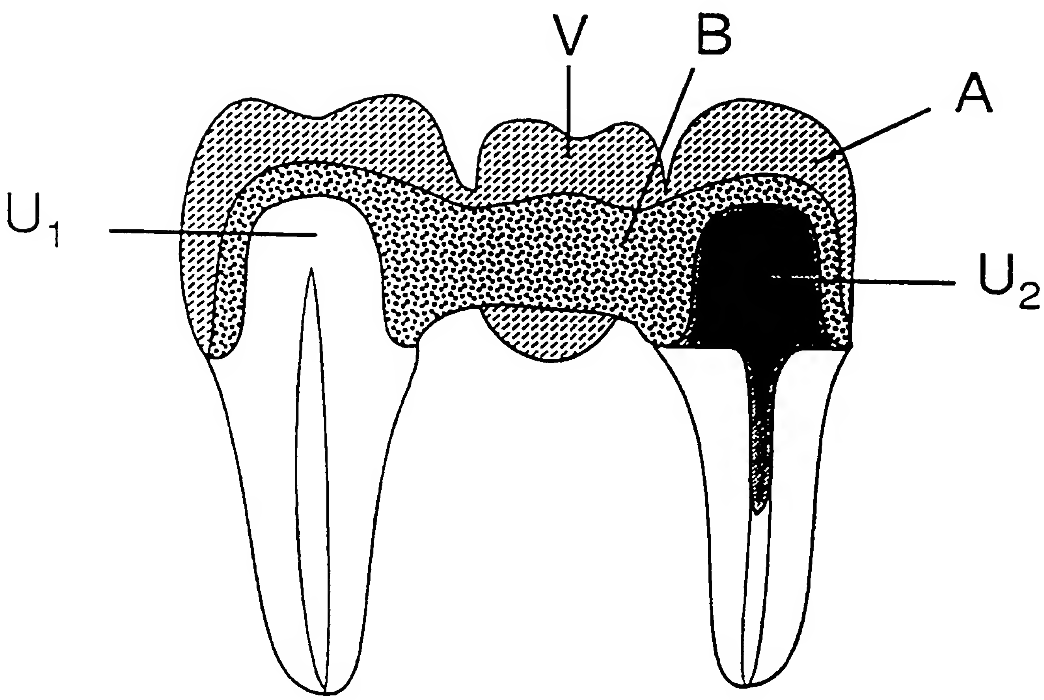

Fig. 2

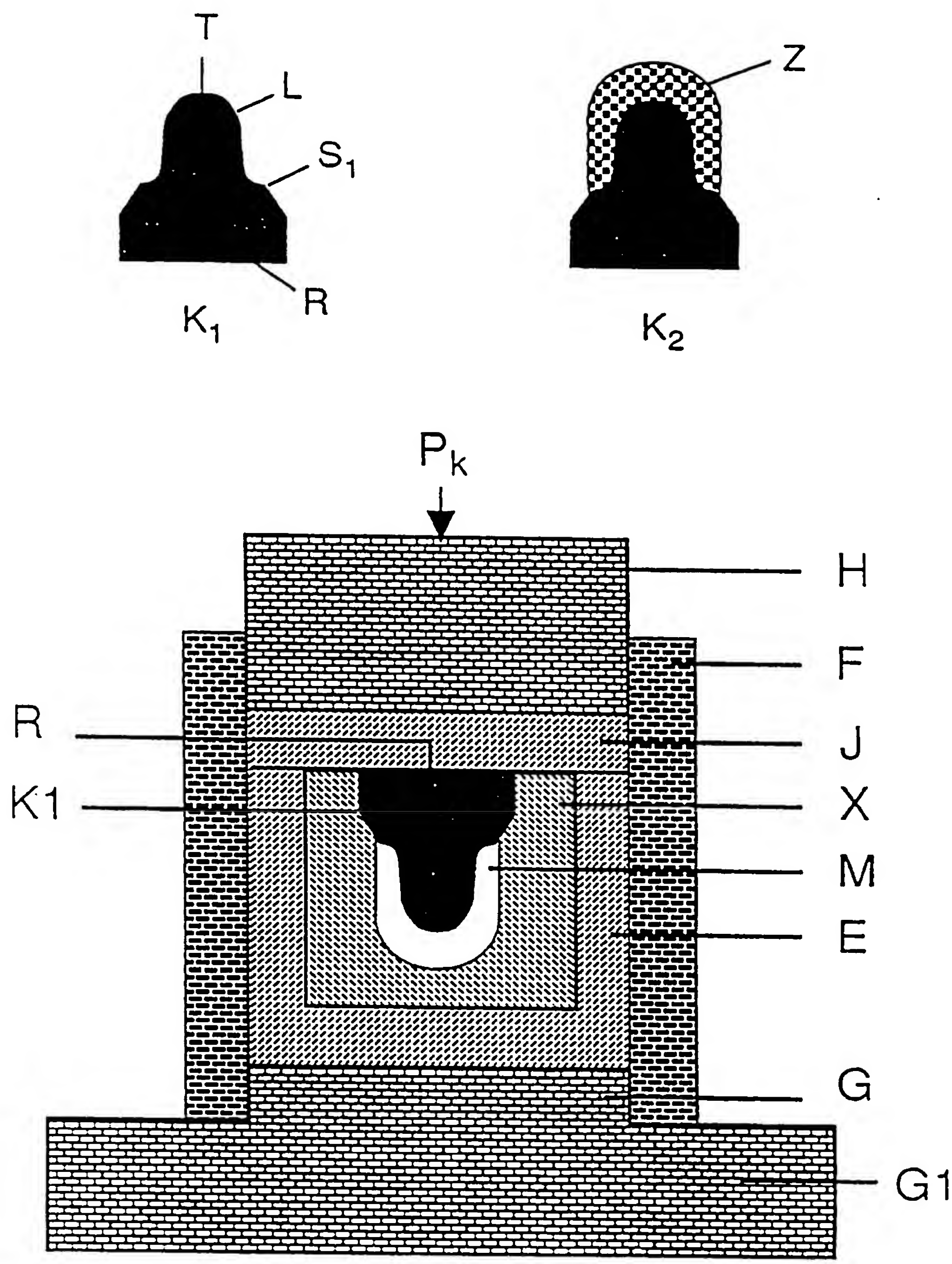

Fig. 3

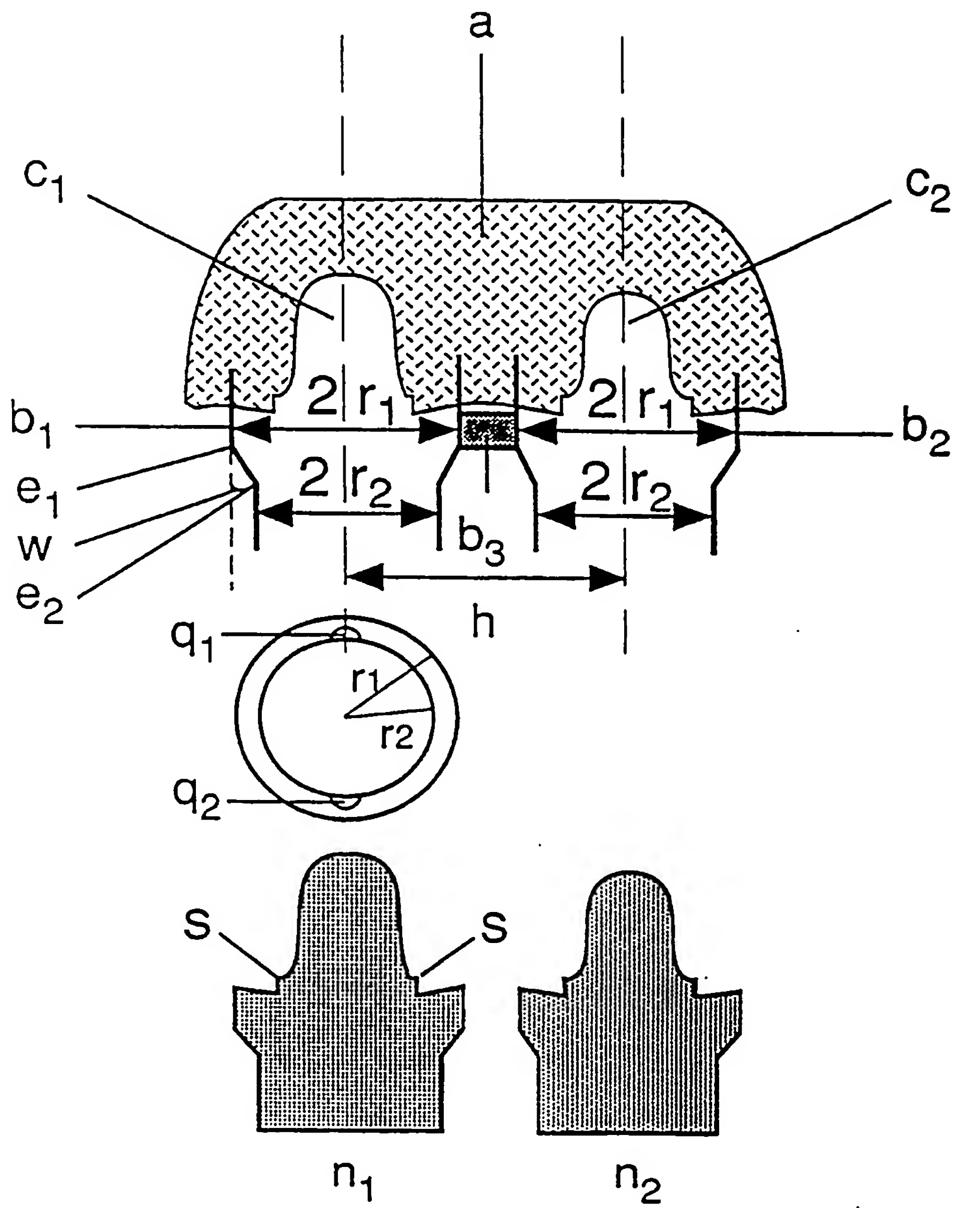

Fig. 4

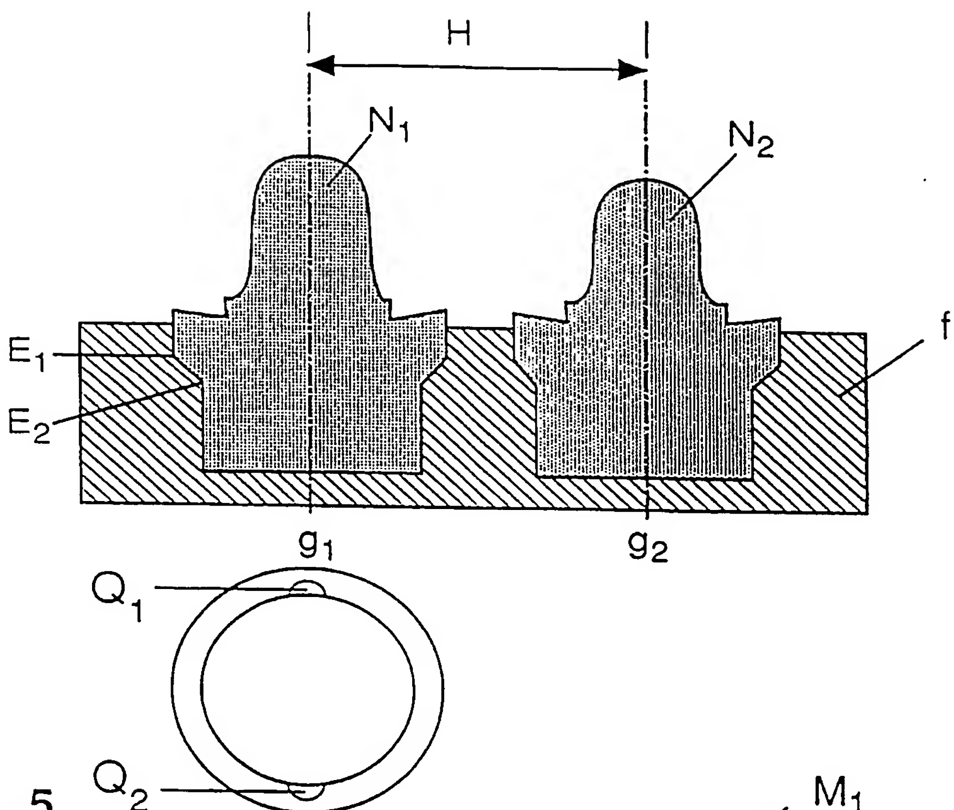

Fig. 5

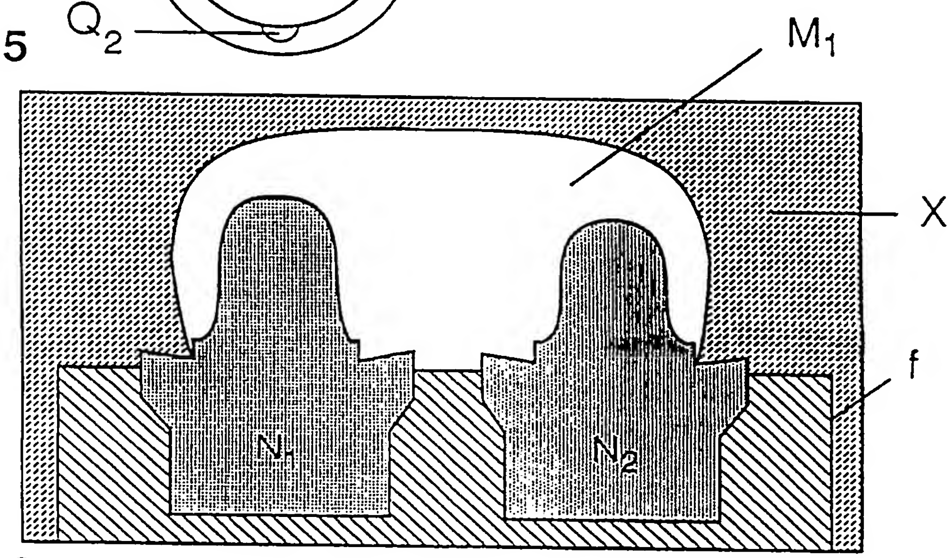

Fig. 6